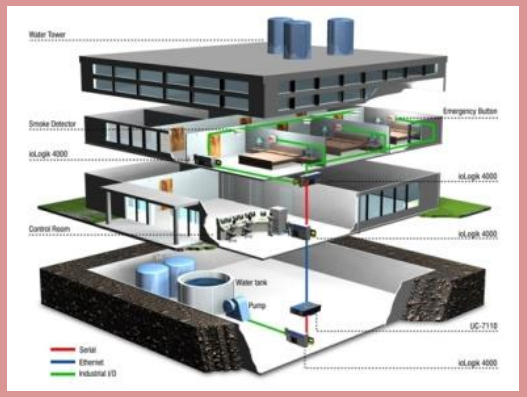
Helwan University
Faculty of Engineering – Matari

بسم الله الرحمن الرحيم



A Course on

Energy Conservation

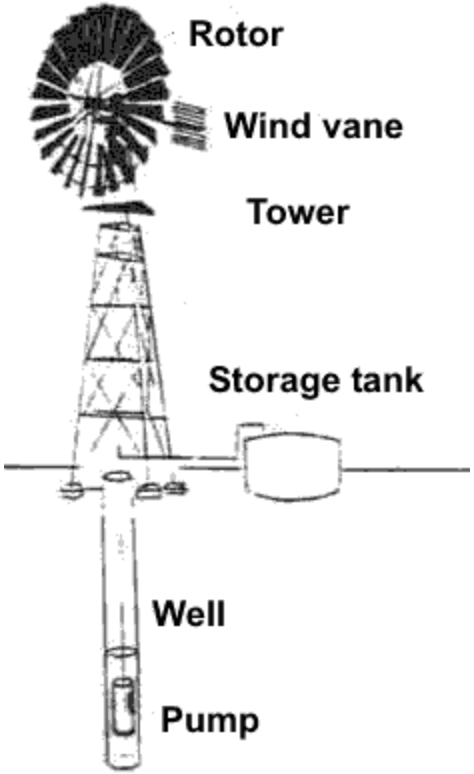
Wind Energy

Ass. Prof. Adel Hussien

November 2012

Introduction

Windmills have been used for many centuries for pumping water and milling grain.

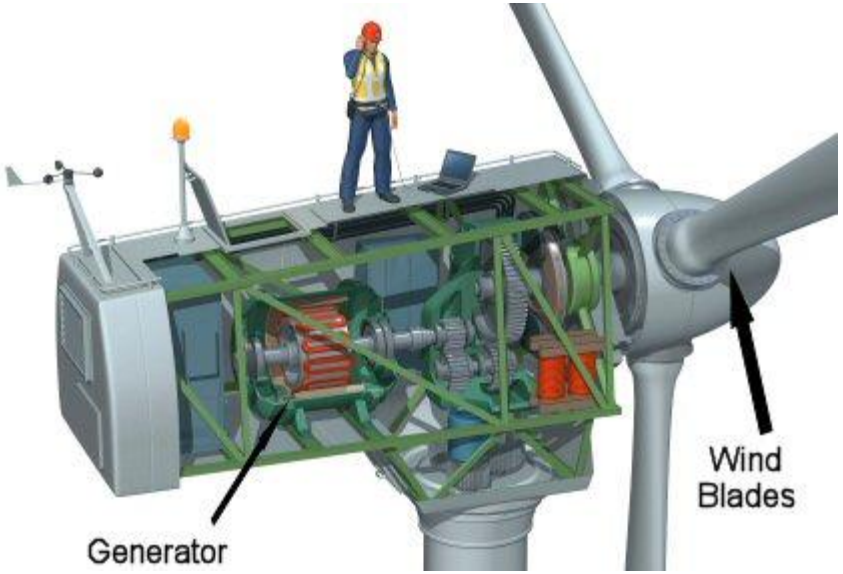


Introduction

In developing countries:

Water supply and irrigation (wind pumps)

Electrical generation (wind generators).



Energy Availability in the Wind

$$\text{Power} = \frac{\text{density of air x swept area x velocity cubed}}{2}$$

$$P = \tfrac{1}{2}.\rho.A.v^3$$

Energy Availability in the Wind

Power density in the wind range

10 W/m² at 2.5 m/s (a light breeze)

41,000 W/m² at 40 m/s (a hurricane)

Energy Availability in the Wind

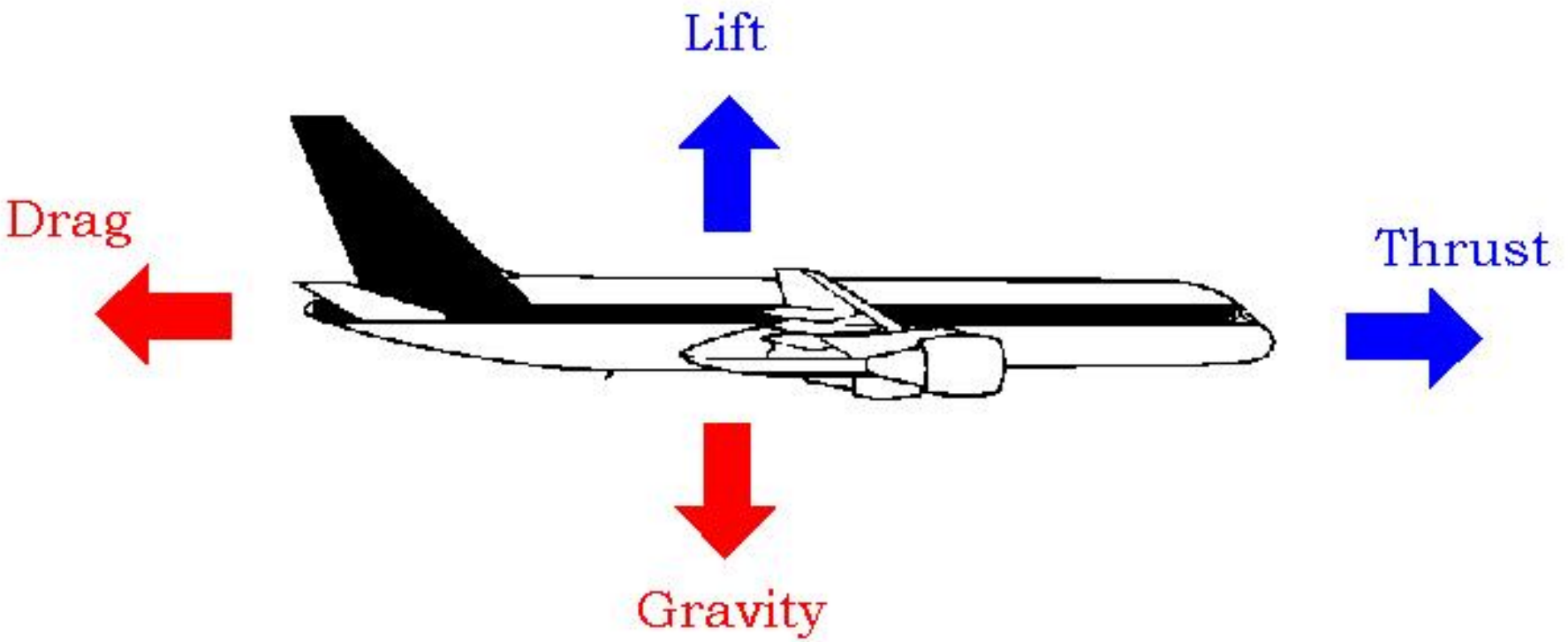
Wind power influences:

- Conversion systems Design
- Construction
- Siting
- Usage
- Economy

The Wind Resource

In large areas of the world appear below 3 m/s, where wind power may or may not be an attractive option.

Principles of Wind Energy Conversion



Principles of Wind Energy Conversion

The basic features that characterize lift and drag are:

1- Drag is in the direction of air flow
2- Lift is perpendicular to the air flow
3- Generation of lift always causes a certain amount of drag to be developed
4- With a good aerofoil, the lift produced can be more than thirty times greater than the drag
5- Lift devices are generally more efficient than drag devices

Types and Characteristics of Windmill Rotors

Vertical axis machines
Horizontal axis machines

Types and Characteristics of Windmill Rotors

Several technical parameters characterize windmill rotors.

Tipspeed

$$\text{Tip speed ratio} = \frac{\text{Bade tip speed}}{\text{Wind speed}}$$

Types and Characteristics of Windmill Rotors

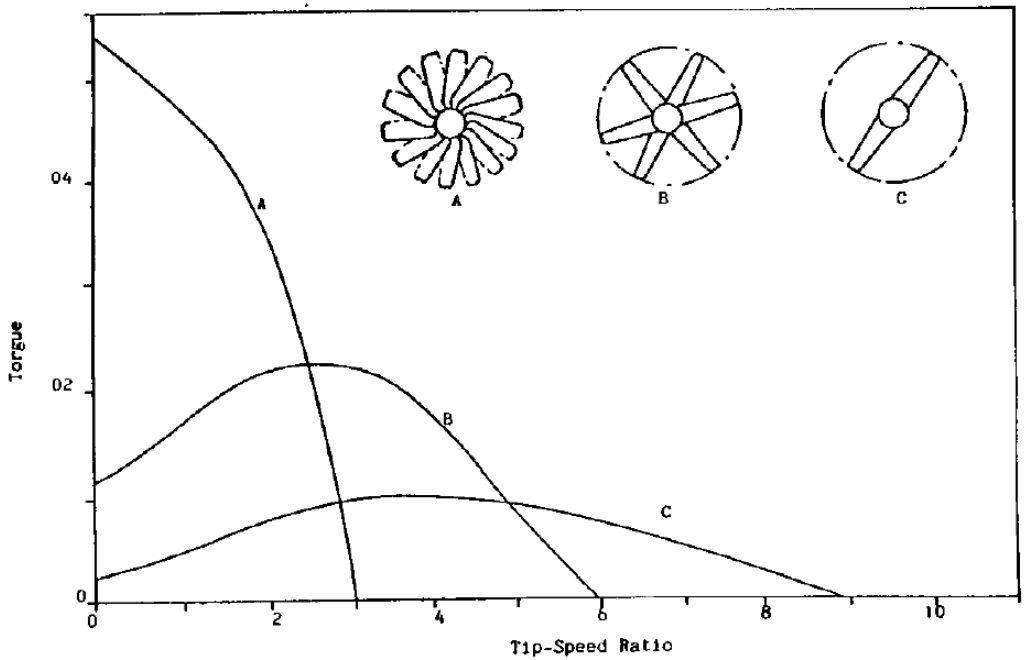
power in the wind that the rotor can extract is

Cp = coefficient of performance

Maximum of 59.3% (Betz limit)
In practice real wind rotors Cp in the range of 25%-45%.

Solidity

Percentage of the circumference of the rotor which contains material rather than air.



Solidity and torque

Solidity

High-solidity machines carry a lot of material and can generate much higher starting torque.

The extra materials also cost more money.

Different rotor types

Type	Speed	Torque	Manufacture	C_p	Solidity %
Horizontal Axis					
Cretan sail	Low	Medium	Simple	.05-.15	50
Cambered plate fan	Low	High	Moderate	.15-.30	50-80
Moderate speed aero-generator	Moderate	Low	Moderate	.20-.35	5-10
High speed aero-generator	High	Very low	Precise	.30-.45	< 5
Vertical Axis					
Panemone	Low	Medium	Crude	> .10	50
Savonius	Moderate	Medium	Moderate	.15	100
Darrieus	Moderate	Very low	Precise	.25-.35	10-20
Variable Geometry	Moderate	Very low	Precise	.20-.35	15-40

Thank you

Any questions